

Diet of the Raccoon dog, *Nyctereutes procyonoides*, in Finland

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Abstract

Studied the diet of the raccoon dog (*Nyctereutes procyonoides*) in Finland by examining the contents of 172 stomachs mainly from August–April and 206 scats from May and June. Findings suggest that the raccoon dog is a true omnivore, with the seasonal composition and diversity of the diet varying with the availability of different food items. Small mammals, plants, and carcasses and other waste were frequently eaten during all seasons, and some birds were eaten throughout the year. Insects were a common food in summer and autumn, and frogs and lizards in late spring and early summer. The diet also included fishes, particularly in early spring and autumn. The annual variation in food composition seemed to be affected by the availability of small rodents. The raccoon dog seems to be rather harmless to full-grown tetraonids and waterfowl, but the role of the raccoon dog in the predation of eggs and downy young of gallinaceous birds and waterfowl remains obscure.

Introduction

The raccoon dog (*Nyctereutes procyonoides* Gray, 1834) originates in the Far East, but the species was introduced to several areas in the northwest of the former Soviet Union in 1935–53 (LAVROV 1971; HELLE and KAUHALA 1987, 1991). From these origins the population soon spread to neighbouring countries, including Finland, and by the mid-1970s the species had colonized southern and central parts of this country. The Finnish population reached a peak in the mid-1980s. It declined slightly thereafter, but is still rather dense in southern Finland (HELLE and KAUHALA 1991).

The food composition of the raccoon dog has previously been studied e.g. in Japan (IKEDA 1985), in different parts of the former Soviet Union (see e.g., BANNIKOV 1964; NAABER 1971; NASIMOVIC and ISAKOV 1985), in the Danube Delta (BARBU 1972), in Poland (REIG and JEDRZEJEWSKI 1988) and in Finland (VIRO and MIKKOLA 1981). The purpose of our work was to examine the annual and seasonal variation in the diet of the raccoon dog in Finland in more detail, with special reference to food composition in late spring and early summer. The diet during that period, i.e. the nesting season of birds, has been a highly controversial, but insufficiently known subject.

Material and methods

We examined 172 stomachs with some content, mainly from animals of southern and central Finland in 1986–90. Most (94 %) of the raccoon dogs were captured by hounds or earth dogs during the hunting season, which lasts from the beginning of August to the end of April. Some were found dead and some were captured in live traps. We also collected 206 scats of raccoon dogs, from the provinces of Häme and Kymi, southern Finland, in May and June 1991. The scats were taken from latrines within a radius of 150 m from the known dens of raccoon dogs.

The contents of stomachs and scats were examined after washing them with water in a sieve (0.5 mm). The food items were identified by comparing them with a reference collection and descriptions in the literature (for identifying mammals, see DAY 1966; SIIVONEN 1974; DEBROT 1982).

The frequencies of occurrence (%) of different food items in the stomachs (Tab. 1) and scats (Tab. 2) were calculated and the volume of the food items was measured. Grasses and herbs, when occurring in very small amounts, were excluded, because they had most probably been eaten accidentally. The remains of raccoon dogs, cervids, pigs or other larger mammals were defined as carcasses, as were pieces of meat with blowfly maggots, and domestic fowl (*Gallus domesticus*). With smaller animals, it is almost impossible to determine whether they had been killed by the raccoon dog itself, which means that some scavenged animals were probably included in groups for birds, mammals or fish instead of carcasses. The occurrence of carcasses of small animals and soft-structured edible waste is almost impossible to determine from scats, and thus they are probably very much underestimated in scats. The stomach data were divided into four seasons: spring (March–May, $n = 53$), summer (June–August, $n = 10$), autumn (September–November, $n = 60$) and winter (December–February, $n = 49$).

We tested seasonal and annual differences in the diet using the G test (SOKAL and ROHLF 1981). We calculated Shannon-Weaver diversity indices and tested the difference between them according to ZAR (1984). The frequency of occurrence of small rodents and of berries in the stomachs was compared with the availability of these food items using regression analysis. The level of significance in the tests was 0.05. The abundance indices of small rodents and wild berries were obtained from game inquiries based on abundance estimates supplied by several hundred observers throughout the country (see HELLE and KAUBALA 1991).

Results

Diet and its seasonal variation: stomachs

The diversity of the diet (using the seven main food categories in Tab. 1) varied somewhat with the season, being higher in the snow-free season than in winter ($P < 0.01$, diversity index for both spring and autumn was 0.78, for summer 0.77 and for winter 0.71; $H'_{\max} =$

Table 1. The frequency of occurrence (%) of main food items in raccoon dog stomachs in different seasons in Finland

Food item	Spring $n = 53$	Summer $n = 10$	Autumn $n = 60$	Winter $n = 49$	Total $n = 172$
Mammals	59	50	62	49	56
Rodents	43	20	43	35	40
<i>Microtus</i> spp.	36	20	40	20	32
<i>Clethrionomys</i> spp.	13	10	17	8	13
<i>Ondatra zibethicus</i>	6	0	2	6	4
Shrews	28	30	28	18	26
Hares	19	0	2	6	8
Birds	42	30	30	33	34
Gallinaceous birds	19	0	3	10	10
Waterfowl	0	0	3	4	2
Passerines	8	20	18	12	13
Reptiles and amphibians	6	30	12	0	8
Frogs	4	30	12	0	7
Lizards	4	20	0	0	2
Fishes	34	10	23	4	20
Invertebrates	32	80	73	37	51
Beetles	9	80	53	8	29
Wasps	4	20	17	25	15
Plants	87	100	92	86	89
Cereals	26	30	43	55	41
Berries	11	30	38	10	22
Fruits and vegetables	34	0	43	20	31
Grass and herbs	62	70	62	39	56
Carcasses and waste	47	50	48	51	49

0.85). The stomach contents were largest in autumn and smallest in winter (mean 139 ml and 53 ml, respectively).

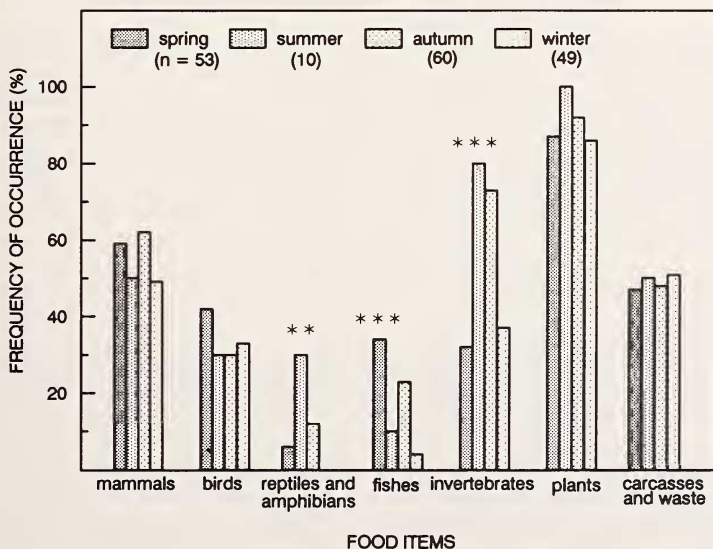
The most common food items in the stomachs were plants, invertebrates, small mammals, and carcasses and other edible waste (Tab. 1, Fig. 1). Some birds, amphibians, reptiles and fish had also been consumed, as had some inedible items. There were no statistical differences in the diet between the sexes or age groups. The only difference between the areas was noticed in the occurrence of carcasses and other waste in the stomachs: in winter and spring, these occurred more frequently in southwestern Finland than farther north ($P < 0.05$).

For seasonal comparison, we combined the data for all years because of the insignificant differences between years. The diet in summer was similar to that in autumn (however, note the small sample for summer). The food composition differed somewhat between spring, summer-autumn and winter (Tab. 1, and Fig.).

Most of the mammals consumed were small rodents, the majority being field voles (*Microtus agrestis*) and bank voles (*Clethrionomys glareolus*). There were, however, also a few muskrats (*Ondatra zibethicus*) and water voles (*Arvicola terrestris*), especially in winter, and harvest mice (*Micromys minutus*) and rats (*Rattus norvegicus*). Shrews (*Sorex* spp.) were also frequently consumed. Some hares (*Lepus* spp.) had been eaten in spring, but hardly at all in the other seasons.

Most of the birds eaten were passerines. Pheasants (*Phasianus colchicus*) were the most common gallinaceous birds, but a few black grouse (*Tetrao tetrix*) and hazel grouse (*Bonasa bonasia*) also occurred. The waterfowl identified in the stomachs were two mallards (*Anas platyrhynchos*), one teal (*Anas crecca*) and one great merganser (*Mergus merganser*).

Egg shells were found in 6 % of the stomachs, in both spring and autumn, but only once in May, when most ground nesting birds start to nest. The other egg shells most probably originated from rubbish heaps, because we found both edible and inedible waste



The frequency of occurrence of seven main food categories in raccoon dog stomachs in different seasons in Finland. The differences between seasons were tested with the G test; the statistical differences are indicated by asterisks (** means $P < 0.01$, *** $P < 0.001$)

in the same stomachs. Thus, these egg shells were most likely those of the domestic fowl, and were counted as the edible waste (Tab. 1).

Frogs (*Bufo bufo* and *Rana* spp.) and viviparous lizards (*Lacerta vivipara*) were occasionally consumed during the snow-free season. Fish occurred in the diet mainly in early spring and autumn.

Most of the invertebrates in the stomachs were insects, mainly beetles and hymenoptera. Wasps (Vespidae) were particularly abundant in winter, and beetles, e.g. Carabidae, Scarabaeidae, Silphidae and Staphylinidae, in summer and autumn. Some ants, earthworms and mollusks had also been consumed.

In spring and early summer, the plant material consumed was mostly grass and other vegetative parts of plants, but in late summer and autumn it was mainly cereal grains, berries, vegetables and fruits. The berries were mostly blueberries (*Vaccinium myrtillus*), lingonberries (*V. vitis-idaea*) and cultivated berries (frequency of occurrence of berries was 52 % in August-October). In winter most of the plant material consumed was cereal grains.

Carcasses and other edible waste (apart from the eggs) were domestic fowl and mammals, e.g. other canids (the red fox and the raccoon dog) and cervids.

Diet in the nesting season of birds: scats

In May and June the most frequent food items in the scats were small mammals (Tab. 2). The majority were voles, but shrews also frequently occurred. Some remains of hares were found. No gallinaceous birds were identified in the scats and we found remains of adult waterfowl in two scats only. Ninety-four percent of the birds were identified as passerines; one bird could not be identified. Some scats contained very small pieces of egg shells, from an unidentified species.

Frogs and viviparous lizards were common in the scats. Almost all the invertebrates found were either beetles or wasps. Most of the plants identified were herbs and grass. Animals classified as carcasses occurred only rarely (4 %) in the scats in May and June. Separate hairs of raccoon dogs were found in 54 % of the scats and in very small amounts; these hairs were probably swallowed, when the raccoon dogs were cleaning their furs.

Annual variation in the diet

Apart from some minor changes, the food composition remained rather similar from year to year. The frequency of occurrence of small rodents in the stomachs correlated positively with their abundance index in autumn in southern Finland ($r = 0.96$, $P < 0.05$), being highest in 1988 and lowest in 1987. In contrast to small mammals, the frequency of occurrence of hares in the diet was higher in spring 1987 than in spring 1988 ($P < 0.001$). Although the frequency of occurrence of berries seemed to correlate

Table 2. The frequency of occurrence (%) of main food items in raccoon dog scats ($n = 206$) collected in southern Finland in May and June 1991

Food item	Frequency of occurrence
Mammals	76
Rodents	52
Shrews	30
Hares	6
Birds	23
Passerines	23
Waterfowl	1
Eggs	9
Reptiles and amphibians	53
Frogs	43
Lizards	39
Fishes	18
Invertebrates	72
Beetles	66
Wasps	18
Plants	22
Cereals	8
Berries	3
Grass and herbs	13

with their abundance index in southern Finland ($r = 0.77$), the correlation was not significant, which, however, may be due to the small sample size.

Discussion

Omnivory of the raccoon dog

The raccoon dog is a true omnivore; the availability of different food items affects both seasonal and annual composition and diversity of the diet. Thus, the raccoon dog probably does not have strong preferences for any food items, except possibly small mammals and berries.

Our results confirm those of other studies: the raccoon dog is omnivorous and the food composition varies somewhat with the area, season and year. However, small mammals, invertebrates and plants seem to be among the commonly consumed food items in most areas (BANNIKOV 1964; NASIMOVIC and ISAKOV 1985), except in Japan, where fish and other marine animals, algae, insects and, during certain seasons, fruits are the main food sources (IKEDA 1985). Frogs are also important prey in some areas (KORNEEV 1954; BARBU 1972; VIRO and MIKKOLA 1981). Birds are eaten to some extent in most areas, but they are not among the most frequent food items in any larger area. The role of carcasses in the diet seems to be rather insignificant in all areas except Finland, scavenging having only occasionally been reported elsewhere (SVIRIDOV 1958; KOSTOGLD 1972), but this may be due to the method used. However, cannibalism is known to occur in other areas also (NASIMOVIC and ISAKOV 1985).

It can be deduced from the morphology that the raccoon dog is a gatherer rather than a predator. Some characteristics of carnivores are only poorly developed (BANNIKOV 1964). The intestine is 1.5–2 times longer than of other canids, the canines are small, the carnassial blades are short, and the molars are large. The raccoon dog is also rather short-legged and clumsy.

Seasonal and annual variation in the diet

The significance of small mammals was probably greatest in spring and autumn; in summer the food supply is so abundant that small mammals are not essential for the raccoon dog. In years when small rodents are scarce, they are to some extent replaced, e.g., by hares. Outside Finland, too, the annual variation in the diet seems to be mostly dependent on the availability of small rodents (MOROZOV 1947; POPOV 1956; GELLER 1959; IVANOVA 1962).

The importance of small mammals as food is seen in the fact that the availability of small rodents even seems to explain some of the annual variation in the numbers of raccoon dogs in Finland (HELLE and KAUFHALA 1991). The abundance of voles affects the fat reserves of females in spring (KAUFHALA, unpubl.) and, thus, the productivity of the population. The abundance of small rodents may also have an effect on the growth and mortality of juveniles.

Birds seem to be of some importance for the raccoon dog in all seasons. However, it is very difficult to establish to what extent the raccoon dogs feed on eggs, because they may break large eggs, and only lap up their contents. The authors have noticed such behaviour among farmed raccoon dogs.

Frogs and lizards are an important food source for the raccoon dog in late spring and early summer, but rather unimportant in other seasons. It is not easy to find remnants of tadpoles or frogspawn in stomachs or scats, and thus the study may underestimate the significance of frogs.

The occurrence of fish in the diet in early spring may be explained by the fact that fish are readily available for the raccoon dogs at that time; ice-fishing is popular in Finland and small fish are often left by fishermen beside the hole on the ice. Tracks of raccoon dogs are

commonly seen on the ice in early spring, when raccoon dogs feed on these fish. These fish may constitute a valuable addition to the diet in some areas, as they are available at a time when other food sources are scarce, and the energy requirement, particularly that of pregnant females, is high.

Invertebrates were frequently eaten in the snow-free season as observed earlier in Finland (VIRO and MIKKOLA 1981). Our study may overestimate the frequency of invertebrates, some of them possibly having been in the stomachs of frogs and lizards eaten by the raccoon dog. On the other hand, a major part of insects eaten consisted of large beetles (Carabidae and Scarabaeidae) that most probably had been caught by the raccoon dogs themselves. Furthermore, the small size of invertebrates compounds the difficulty of assessing their importance as a food source for the raccoon dog, as the frequency of occurrence may be misleading. For instance, the occurrence of invertebrates during summer and autumn was 74 %, whereas their proportion by volume was only 6 %. But volume, also, can be misleading, as it is greatly affected by the time elapsing since the last meal and the digestibility of food (ENGLUND 1965).

Plants are an important year-round food source for the raccoon dog. Of particular interest is the role of berries in the diet of the raccoon dog; half of the stomachs in August-October contained them. This figure probably underestimates the real importance of berries, because berries are easily digested and do not remain for long periods in the stomachs. Berries seemed to be most common in the stomachs in 1988, a year of abundant blueberries and lingonberries. NASIMOVIC and ISAKOV (1985) point out that the crop of berries and fruits can affect the yearly variation in the diet. And further, the abundance of berries seems to affect even the yearly variation in numbers of raccoon dogs, as it most probably affects the mortality of juveniles during their first autumn and winter and, thus, the population density in the following spring (HELLE and KAUBALA 1991).

Almost half of the stomachs contained carcasses or other edible waste, indicating the importance of carcasses and rubbish heaps to the raccoon dog. The occurrence of various inedible items, including rubber bands, and pieces of newspaper and plastic, in the stomachs also indicates frequent visits to rubbish heaps. Rubbish heaps seem to be important in all seasons, but most of all in winter and early spring, when there is a shortage of other food. According to VIRO and MIKKOLA (1981), carcasses were the most important food source for raccoon dog in winter, but not during the snow-free season. In our study, waste and carcasses were more commonly consumed in southwestern Finland than farther north. This is a result of higher availability of such sites due to dense human population. Winters are also warmer in the south, and raccoon dogs sleep for a shorter period. As a result, they are actively moving around in winter and early spring, when other food sources are scarce.

Small game animals in the diet

This study provides no evidence that the raccoon dog is highly harmful to game bird populations. The birds most commonly identified in the stomachs and scats were passerines; there were no remains of tetraonids in scats in May and June. However, we did find some gallinaceous birds in the stomachs in spring. Moreover, there were some remains of waterfowl in the scats, so the raccoon dog may have killed incubating females. (The raccoon dog is most likely unable to catch other healthy adult birds.) It is of course possible that the birds had been found dead. However, as mentioned above, we do not have much knowledge of egg predation by the raccoon dog in Finland.

We found remains of waterfowl in the stomachs only in autumn and winter. They had most probably been injured or were dead because we sometimes found shots in the same stomachs, as did NAABER (1974) in Estonia.

OBTEMPERANSKIJ (1958) found birds only in 3 % of the scats in a forest area in Voronez (European Russia) in late spring and early summer. However, IVANOVA (1962) found

remains of birds in 45 % of the scats in a river valley in the same large area. Most of these birds were waterfowl, but a few passerines and domestic fowl were also found. Pieces of egg shells were rarely found (in 3 % of the scats).

NAABER (1971, 1984) found that in some sites in Estonia raccoon dog can be very harmful to waterfowl; they have robbed even 85 % of the nests. In the Matsalu area (seashore nature reserve area) birds occurred in 31 % and egg shells in 33 % of the scats in spring. However, according to NAABER (1971) the raccoon dog appeared to be harmless to other game animals, such as gallinaceous birds and hares.

REIG and JEDRZEJSKI (1988) compared the diets of five mammalian predators in Bialowieza National Park in Poland in winter and spring. They found that more than 90 % of the birds preyed upon were eaten by the red fox. Also NAABER (1974) considered the red fox much more harmful to game animals than the raccoon dog. In the Far East, JUDIN (1977) found birds in 5–20 % of the scats in spring, 4–6 % in summer, the proportion of gallinaceous birds and waterfowl ranging from 0–4 %. These findings from other localities also support the idea that the raccoon dog poses little danger to game birds in most areas, but it may be harmful in some special sites, e.g., in waterfowl colonies.

The few hares in the stomachs and scats were probably juveniles, because hares occurred in the stomachs mostly in spring, and adult hares are far too quick to be caught by the raccoon dog. We found remains of hares only in four stomachs in autumn and winter, and it is questionable whether the raccoon dogs themselves had killed these hares or if the hares had been killed, e.g., by traffic.

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Zusammenfassung

Die Nahrung des Marderhundes, Nyctereutes procyonoides, in Finnland

Die Nahrung des Marderhundes (*Nyctereutes procyonoides*) in Finnland wurde untersucht, indem hauptsächlich von August bis April der Inhalt von 172 Mägen und im Mai und Juni 206 Kotballen analysiert wurden. Die Befunde weisen darauf hin, daß der Marderhund ein typischer Allesfresser ist, bei dem die saisonale Zusammensetzung und Vielfalt der Nahrung je nach Verfügbarkeit der verschiedenen Nahrungsbestandteile variiert. Kleine Säugetiere, Pflanzen, Aas und andere Abfälle fraß der Marderhund zu allen Jahreszeiten häufig, und auch einige Vogelarten dienten ihm rund um das Jahr als Nahrung. Insekten waren im Sommer und im Herbst eine häufige Nahrung Frösche und Eidechsen im späten Frühling und im Frühsommer. Zur Nahrung gehörten auch Fische, vor allem im Frühling und Herbst. Die jährliche Variation in der Zusammensetzung der Nahrung schien vom Vorhandensein kleiner Nagetiere abzuhängen. Für erwachsene Tetraoniden und Wasservögel scheint der Marderhund weitgehend ungefährlich zu sein, aber inwieweit er für den Raub von Eiern und Brut der Hühner- und Wasservögel verantwortlich ist, bleibt nach wie vor unklar.

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